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Tuning the Structural, Electrical and Optical Properties of Tin Oxide Thin Films via Cobalt Doping and Annealing

A. M. El Sayed[a*], S. Taha[a], Mohamed Shaban[b], G. Said[a]

[a] Department of Physics, Faculty of Science, Fayoum University, Fayoum 63514, Egypt

[b] Nanophotonics and Applications Lab, Department of Physics, Faculty of Science, Beni-Suef University, 62514, Egypt

Abstract

Pure and cobalt-doped SnO_2 ($Sn_{1-x}Co_xO_2$, $0 \leq x \leq 0.09$) thin films were grown by dissolving $SnCl_2.2H_2O$ in ethanol and spin coating on glass substrates. The X-ray diffraction and Raman analysis show that the films are polycrystalline and correspond to the rutile phase with a preferred orientation along (110) direction. The grain size and crystallinity of the films that annealed at 450 ^oC for 1.0 h are enhanced after annealing at 500 ^oC for 2.0 h. According to atomic force microscopy (AFM), the films consist of grains influenced by doping and annealing temperature and time. I–V measurements reveal non-Ohmic contacts of the films with the electrodes. Transmittance spectra, optical band gap (E_g), Urbach energy (E_U), refractive index, film thickness, and the optical constants of the films are dependent on the Co content and annealing conditions. The obtained results illustrate the possibility of controlling the film's physical properties for the optoelectronic devices and applications.

Keywords: SnO_2 thin films; Raman shift; Spin coating; I-V characteristics; Refractive index; Conductivity.